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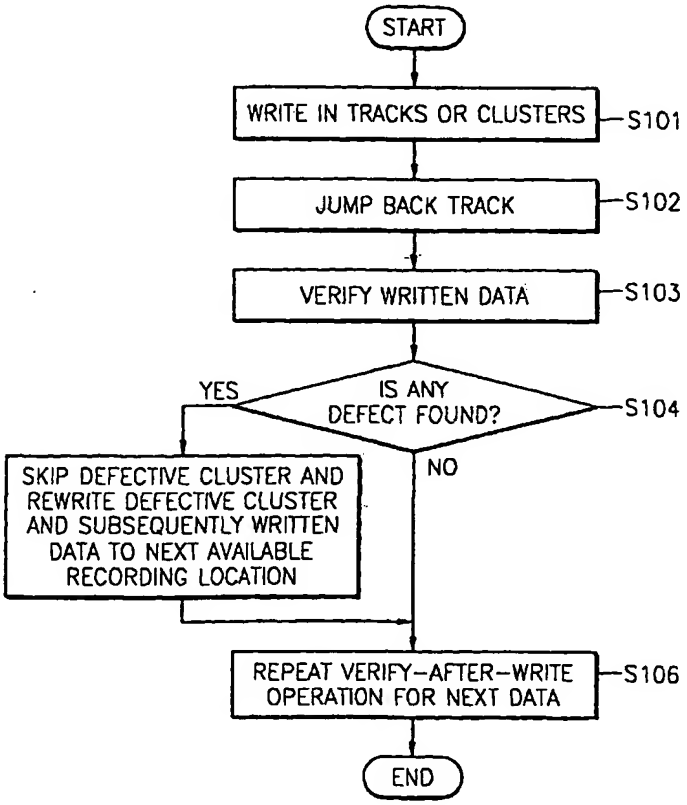

(57) Abstract: A high density write-once recording medium allowing defect management, and a method and apparatus for managing defects are provided. According to the high density writing-once recording medium, data is written to the recording medium in tracks or clusters, the written data is verified, and if a defect is found a defective portion is skipped and data corresponding to the defective portion and the following written data are rewritten on a next available recording location. The defect management method using slipping replacement is applied to the high density write-once recording medium in which defects are found, thereby allowing continued recording by slipping defects found in the recording medium and further increasing the reliability of the recording medium.

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HIGH-DENSITY WRITE-ONCE RECORDING MEDIUM ALLOWING DEFECT MANAGEMENT, AND METHOD AND APPARATUS FOR MANAGING DEFECTS

Technical Field

The present invention relates to the field of defect management on recording media, and more particularly, to a high density write-once recording medium that allows defect management via a slipping replacement in a defective region while performing recording in a verify-after-write mode, and a defect management method and apparatus.

Background Art

Conventionally, a defect management method has been used only for media on which data can be re-recorded and can be random accessed. In the case of media that can be written just once, that is, write-once recording media, a defect management method is not yet available due to the characteristics of the media.

Typically, defect management schemes using linear replacement and slipping replacement algorithms have been used. In a defect management method using linear replacement, when a defect occurs in a sector in a recording area while the media is being used, the defective sector is replaced with a sector from a spare area. The linear replacement algorithm is used for the recording media that allows repeated recording but is not usable as a real-time recording format.

According to a defect management method using slipping replacement, a defective sector is skipped and data start being recorded on the next available sector. That is, if defects are found in one area, subsequent data is recorded in an area after a corresponding number of defective sectors have been skipped. Thus, in this method, defects are checked for upon initialization of media and a logical sector address for

recording user data is not assigned to defective sectors, so that the defective sectors are unavailable for use.

In conventional recording media, the method using slipping replacement is used to skip over defective sectors found upon initialization of media or before use after checking for defects.

Thus, the defect management using linear replacement has a problem in that it can not be used for write-once recording media which do not support random access. Also, the method using slipping replacement cannot be used as is for write-once recording media since the recording medium on which data cannot be erased/re-recorded once written cannot perform certification for checking for any defects before use.

Meanwhile, for next-generation write-once recording media using laser, high density write-once recording media have been developed using blue laser technology and multi-layer recording, following Compact Disc-Recording (CD-R) and Digital Versatile Disc-Recording (DVD-R). The high density write-once recording media provide recording capacity up to tens of gigabytes (GBs) in the same size as the existing media at an affordable price. Furthermore, since this media allow quick read speed and random access unlike backup media such as tapes, they can used, in particular, as backup to large capacity computer storage devices. However, this media have a drawback that, in the case of requiring a batch backup during nighttime when not much users do not access the system, backup is not executed and ceases to operate upon occurrences of a defect during the backup.

Disclosure of the Invention

The present invention provides a high density write-once recording medium allowing a defect management.

The present invention also provides a high density write-once recording medium that allows for a defect management using slipping replacement in a defective region while data are recorded in a verify-after-write mode.

The present invention also provides a defect management method in which slipping replacement is used for a defective region while data is being recorded on the high density write-once recording medium in a verify-after-write mode.

Furthermore, the present invention provides a defect management apparatus which uses slipping replacement for a defective region while data is being recorded on the high density write-once recording medium in a verify-after-write mode.

According to an aspect of the present invention, there is provided a high density write-once recording medium. In the high density write-once recording medium, data is written in predetermined recording units, the data is verified after writing, no data is written on a defective portion if a defect is found therein, and data corresponding to the defective portion and the following written data are rewritten on a next available recording location. Here, the predetermined recording unit is a track comprised of a predetermined number of clusters or a cluster.

According to another aspect of the present invention, there is provided a defect management method used for a high density write-once recording medium. The method includes the steps of: writing data in predetermined recording units and verifying the written data; and skipping a defective portion if a defect is found during the verification and rewriting data corresponding to the defective portion and the following written data on a next available recording location. Here, the predetermined recording unit is a track comprised of a predetermined number of clusters or a cluster.

According to yet another aspect of the present invention, there is provided a recording/reproducing apparatus for performing defect management for a high density write-once recording medium, the apparatus having a driver that drives the recording medium, an optical pickup that reads/writes data from the recording medium by irradiating laser beams onto the recording medium, and a signal processor that modulates data into a signal for recording data and demodulates a recorded signal back to the original data. The apparatus also includes a controller that controls the operation of verifying data, which has been written in predetermined recording units to a recording area on the recording medium through the signal processor and the optical pickup and read through the optical pickup and the signal processor after the data have been recorded, and if a defect is found, the controller controls the operation of skipping a defective portion and rewriting data corresponding to the defective portion and subsequently written data to a next available recording location on the recording medium through the signal processor and the optical pickup. The apparatus further includes a memory that temporarily stores information about the skipped defective portion and subsequently written data.

Brief Description of the Drawings

FIG. 1 shows a schematic example for illustrating a defect management method in which slipping replacement is used while data is being recorded on a high density write-once recording medium in a verify-after-write mode;

FIG. 2 shows another schematic example for illustrating a defect management method in which slipping replacement is used while data is being recorded on a high density write-once recording medium in a verify-after-write mode;

FIG. 3 is a flowchart showing a defect management method for a high density write-once recording medium according to an embodiment of this invention; and

FIG. 4 shows the configuration of a recording/reproducing apparatus for performing defect management for a high density write-once recording medium according to an embodiment of this invention.

Best mode for carrying out the Invention

To perform a defect management method for a high density write-once recording medium according to this invention, slipping replacement can be used instead of linear replacement that is suitable for recording media that allow repeated recording. However, since the high-density write-once recording medium cannot perform a certification process during which defects are checked before using the medium, in this invention, data is recorded in a verify-after-write mode which requires that after a portion of data has been written the recorded portion should be verified. If it turns out that the corresponding portion of data has been normally recorded, the next portion of data is then recorded. If the portion of data is found to contain a defective portion, the defective portion is skipped by slipping replacement and data corresponding to the defective portion and data recorded on the following portion are rewritten to the next available region. In this way, a defect management method is used for the high-density write-once recording medium, increasing reliability of the medium. Here, the portion of data is written in a predetermined recording unit. The predetermined recording unit can be one track corresponding to the number of clusters that can be recorded during one revolution of the disc or one cluster.

Since the recording medium requires error correction coding for performing error correction and interleaving of error correction blocks used to record the error correction blocks on physically scattered locations on the disc to enhance tolerance to physical defects on data, the smallest unit that can be recorded is limited to a cluster or error correction block. This smallest writable unit is defined as a recording cluster or just a cluster.

FIG. 1 shows a schematic example for illustrating a defect management method for a high density write-once recording medium, in which slipping replacement is used while data is being recorded in a verify-after-write mode. Particularly, this example shows a case where data is written on one recording track and read back for verification. This defect management method using slipping replacement while performing a verify-after-write mode in tracks minimizes the distance covered by a pickup allowing high speed recording, whereas it decreases the efficiency of use for user data area since data recorded after a defective cluster need to be rewritten.

Here, the unit in which data can be processed is divided into a sector and a cluster. The sector is the smallest unit in which data can be managed in a computer file system or application program, while the cluster is the smallest unit in which data can be written on the disc at a time. In general, one cluster is comprised of one or more sectors. Sectors are classified into physical and logical sectors. A physical sector refers to a space for recording one portion of data on the disc, and for addressing purposes is assigned a separate physical sector number (PSN). A logical sector refers to a unit in which data can be managed in a file system or application program, and is assigned a separate logical sector number (LSN). A recording/reproducing apparatus for recording/reproducing data on a disc uses a physical sector number to locate data to be recorded, and a computer or application program for recording data manages the entire data by logical sectors and the location of data by specifying LSNs. A controller in the apparatus converts relationship between LSN and PSN using the presence of defects and the location where recording starts.

Referring to FIG. 1, a pickup of the recording/reproducing apparatus writes one track of user data LSN=n, LSN=n+1*k, LSN= LSN=n+2*k, LSN=n+3*k, LSN=n+4*k, and LSN=n+5*k on a recording track and then jumps back to the original track. Here, one recording

track is comprised of a predetermined number of clusters, each cluster having k sectors.

If defects are found when the pickup jumps back to the start position of the track and reads the written data for verification, clusters ranging from the defective cluster LSN=n+4*k to the last cluster within the track are slipped past and the clusters including the defective cluster and the following clusters are rewritten on the next available track. In this case, information about the skipped clusters is stored in a temporary storage memory in the recording/reproducing apparatus.

Conversely, when the one track of data is read back for verification and data has been normally recorded without any defects, verify-after-write operation is repeated for the next track of user data to be recorded.

Although it is possible to record and verify data in tracks and then re-record only a defective cluster on a new recording area, this method has no substantial advantages in that it not only requires information about the defective cluster, a new recording area where the defective cluster is recorded, and normal clusters residing between the defective cluster and new recording area, but also requires complicated processing for the recording/reproducing apparatus to read the data thus recorded.

FIG. 2 shows another schematic example for illustrating a defect management method for a high density write-once recording medium, in which slipping replacement is used while data is being recorded in a verify-after-write mode. Particularly, this example shows a case where data is written in clusters and read back for verification. This defect management method using slipping replacement while performing a verify-after-write mode in clusters increases the use efficiency of user data area but slows down the recording speed.

Referring to FIG. 2, when the pickup writes user data on each cluster and then jumps back to the original track for verification, if defects are not found, verify-after-write operation is repeated for the next cluster of user data to be recorded.

If defects are found when the pickup jumps back to the original track, more particularly, to the beginning of the track and reads one cluster of the written data LSN=n+4*k for verification past normal clusters LSN=n, LSN=n+1*k, LSN= LSN=n+2*k, and LSN=n+3*k, only the defective cluster LSN=n+4*k is skipped and user data corresponding to the defective cluster is rewritten on the next available cluster. In this case, information about the skipped cluster is stored in a temporary storage memory in the recording/reproducing apparatus.

After a verify-after-write operation is repeated to skip all defective clusters and write all user data that has to be recorded, information on defects stored in the temporary storage memory is recorded on a predetermined area reserved for recording appropriate defect management information on the disc. This allows new data to be recorded on an area subsequent to the area where the previous user data has been recorded since some unused user data areas are left empty. Also, this makes it possible to locate the area where data has been normally recorded skipping the defective region when recording the recorded data.

A method of repeating verify-after-write operation by clusters involves jumping back to the original track in order to read back and verify the written cluster because data is read from or written to a rotating disc by laser beams. Thus, this method decreases the recording speed by the time taken for the disc to rotate from the beginning of the original track till the cluster recorded within the track. However, this approach also makes it possible to skip only the defective clusters, thereby increasing the efficiency of use for user data area.

On the other hand, a method of repeating the verify-after-write operation by tracks increases the writing speed by writing and verifying clusters corresponding to one track during the same period of time necessary to perform verify-after-write operation for one cluster. However, this approach involves rewriting the defective cluster as well as all subsequently recorded clusters in order to maintain the sequential

order of logical sector numbers of the recorded data, thereby decreasing the efficiency of use for data recording areas. To increase the writing speed, it is possible to write two or more tracks at the same time. However, this method cannot increase the writing speed much since it will simply reduce the time by the difference between the time taken to perform one track jump backward for all tracks and that taken to perform jump backward for all tracks in units of two or more tracks. If defects occur at the beginning of a unit of two or more tracks to be recorded, it causes greater loss of recording areas.

FIG. 3 is a flowchart showing a defect management method for a high density write-once recording medium according to an embodiment of this invention. Referring to FIG. 3, the defect management method includes the steps of: writing user data in one recording unit - one track or one cluster (S101); jumping back to the original track (S102); verifying the data written on the track (S103); determining whether there is a defect in the recorded data (S104); and rewriting the defective cluster and all following clusters of data on the next available area if the defect is found (S105). In the step S105, in the case of performing verify-after-write for each track as shown in FIG. 1, the defective cluster and all subsequent clusters are skipped and corresponding data are rewritten on the next available track. In the case of performing verify-after-write for each cluster as shown in FIG. 2, only the defective cluster is skipped, and data corresponding to the defective cluster is rewritten on the next available cluster. If no defect is found in the step S104, a verify-after-write operation is repeated in tracks or clusters in the step S106.

FIG. 4 shows the configuration of a recording/reproducing apparatus for performing defect management for a high density write-once recording medium according to an embodiment of this invention. The recording/reproducing apparatus consists of a driver 20 for driving a disc 10, that is, a recording medium, an optical pickup 30 that reads/writes data from/to the disc 10 by irradiating laser beams onto

the disc 10, a signal processor 40 that modulates data onto a signal for recording data and demodulates a recorded signal back to the original data, a controller 50 that controls each block, and a memory 60 that temporarily stores data to be recorded and records information necessary for defect management.

Referring to FIG. 4, data to be recorded received for recording through the controller 50 is written to the disc 10 through the signal processor 40 and the optical pickup 30, and a location on the disc 10 where data is written is adjusted by the driver 20. The controller 50 controls the location where data is written and the amount of data. The written data is read through the optical pickup 30 and the signal processor 40 according to the control by the controller 50. The controller 50 compares data read from written area with currently written data residing in the memory 60, and if a defect is found, the controller rewrites a defective cluster and subsequently written data to a new recording area on the disc 10 through the signal processor 40 and the optical pickup 30, and records information about the defective cluster and subsequently written data on the memory 60 which is a temporary storage area. After the verify-after-write operation is performed sequentially to write all data to be recorded, under the control of the controller 50, the information about defects stored in the memory 60 is read and written to a predetermined area on the disc 10 through the signal processor 40 and the optical pickup 30.

Industrial Applicability

As described above, this invention applies a defect management method to a high density write-once recording medium, using slipping replacement while data is being recorded in a verify-after-write mode, thereby allowing continued recording by slipping defects found in the recording medium and further increasing the reliability of the recording medium.

Furthermore, when a high density write-once recording medium is used for batch backup in a large-capacity computer storage device, a defect management method using slipping replacement according to this invention enables the recording medium to execute seamless backup even when defects occur in the recording medium, thereby preventing a backup operation from being interrupted. That is, this eliminates the need to restart a backup operation or replace the recording medium with a new one, thus enhancing the reliability of the system.

While this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A high density write-once recording medium wherein data is written in predetermined recording units,

wherein the data is verified after it was written in the predetermined recording units, and if a defect is found, no data is written in a defective portion, and

wherein data corresponding to the defective portion and the following written data are rewritten in a next available recording location.

2. The recording medium of claim 1, wherein the predetermined recording unit is a track comprised of a predetermined number of clusters.

3. The recording medium of claim 1, wherein the predetermined recording unit is a cluster.

4. The recording medium of claim 1, wherein information about the defect existing on the recording medium is further recorded in a predetermined area.

5. A high density write-once recording medium recorded using a laser beam, wherein

data is written in track units, each track being comprised of a predetermined number of clusters,

wherein the data is verified after it was written on each track, and if a defect is found, no data is written to clusters ranging from a defective cluster to the last cluster in the track, and

wherein data corresponding to the defective cluster and the following written clusters are rewritten on a next available track.

6. The recording medium of claim 5, wherein information about the defect existing on the recording medium is further recorded in a predetermined area.

7. A high density write-once recording medium recorded using a laser beam, wherein

data is written in cluster units,

wherein the data is verified after it was written on each cluster, and if a defect is found, no data is written on a defective cluster, and

wherein data corresponding to the defective cluster is rewritten on a next available cluster.

8. The recording medium of claim 7, wherein information about the defect existing on the recording medium is further recorded in a predetermined area.

9. A defect management method used for a high density write-once recording medium, the method comprising the steps of:

writing data in predetermined recording units and verifying the written data; and

skipping a defective portion if a defect is found during the verification and rewriting data corresponding to the defective portion and the following written data on a next available recording location.

10. The method of claim 9, further comprising the step of repeating a verify-after-write operation for next recording unit of data if no defect is found in the recording unit during the verification.

11. The method of claim 9, further comprising the step of storing information about the skipped defective portion and following written data in a temporary storage area.

12. The method of claim 11, further comprising the step of recording information about the defect existing on the recording medium in a predetermined area on the recording medium using the information stored in the temporary storage area.

13. The method of claim 9, wherein the predetermined recording unit is a track comprised of a predetermined number of clusters.

14. The method of claim 9, wherein the predetermined recording unit is a cluster comprised of a predetermined number of sectors.

15. A defect management method used for a high density write-once recording medium recorded using a laser beam, the method comprising the steps of:

writing data on a track comprised of a predetermined number of clusters, and verifying the written data; and

skipping clusters ranging from a defective cluster to the last cluster in the track if a defect is found in the track during the verification, and rewriting data corresponding to the defective cluster and the following written clusters on a next available track.

16. The method of claim 15, further comprising the step of repeating a verify-after-write operation for next track of data if no defect is found in the track during the verification.

17. The method of claim 15, further comprising the step of storing information about the skipped defective cluster and following written clusters in a temporary storage area.

18. The method of claim 17, further comprising the step of recording information about the defect existing on the recording medium in a predetermined area on the recording medium using the information stored in the temporary storage area.

19. The method of claim 15, wherein the verification comprises the steps of:

writing data on a track comprised of a predetermined number of clusters;

jumping back to the original track; and

reading and verifying the data written on the track.

20 A defect management method used for a high density write-once recording medium recorded using a laser beam, the method comprising the steps of:

writing data on a cluster; and verifying the written data; and

skipping a defective cluster if a defect is found in the cluster during the verification, and rewriting data corresponding to the defective cluster on a next available cluster.

21. The method of claim 20, further comprising the step of repeating a verify-after-write operation for next cluster of data if no defect is found in the cluster during the verification.

22. The method of claim 20, further comprising the step of storing information about the skipped defective cluster in a temporary storage area.

23. The method of claim 22, further comprising the step of recording information about the defect existing on the recording medium

in a predetermined area on the recording medium using the information stored in the temporary storage area.

24. The method of claim 20, wherein the verification comprises the steps of:

writing data on a cluster;

jumping back to one track; and

reading and verifying the data written on the cluster.

25. A recording/reproducing apparatus for performing defect management for a high density write-once recording medium, the apparatus including a driver that drives the recording medium, an optical pickup that reads/writes data from the recording medium by irradiating a laser beam onto the recording medium, and a signal processor that modulates data onto a signal for recording data and demodulates a recorded signal back to the original data, and a controller that controls the operation of verifying data, which has been written in predetermined recording units to a recording area on the recording medium through the signal processor and the optical pickup and read through the optical pickup and the signal processor after the data, and if a defect is found controls the operation of skipping a defective portion and rewriting data corresponding to the defective portion and subsequently written data to a next available recording location on the recording medium through the signal processor and the optical pickup.

26. The apparatus of claim 25, further comprising a memory that temporarily stores information about the skipped defective portion and subsequently written data.

27. The apparatus of claim 26, wherein after verify-after-write operation is performed sequentially to write all data to be recorded, the controller controls the operation of writing the information about defects

stored in the memory to a predetermined area on the recording medium through the signal processor and the optical pickup.

28. The apparatus of claim 25, wherein the driver adjusts a location on the recording medium where data is written, and the controller further controls the location where data is written and the amount of data to be recorded and compares data read from an area where data has been written with currently written data residing in the memory and verifies if a defect is found.

29. The apparatus of claim 25, wherein the predetermined recording unit is a track comprised of a predetermined number of clusters.

30. The apparatus of claim 25, wherein the predetermined recording unit is a cluster.

FIG. 1

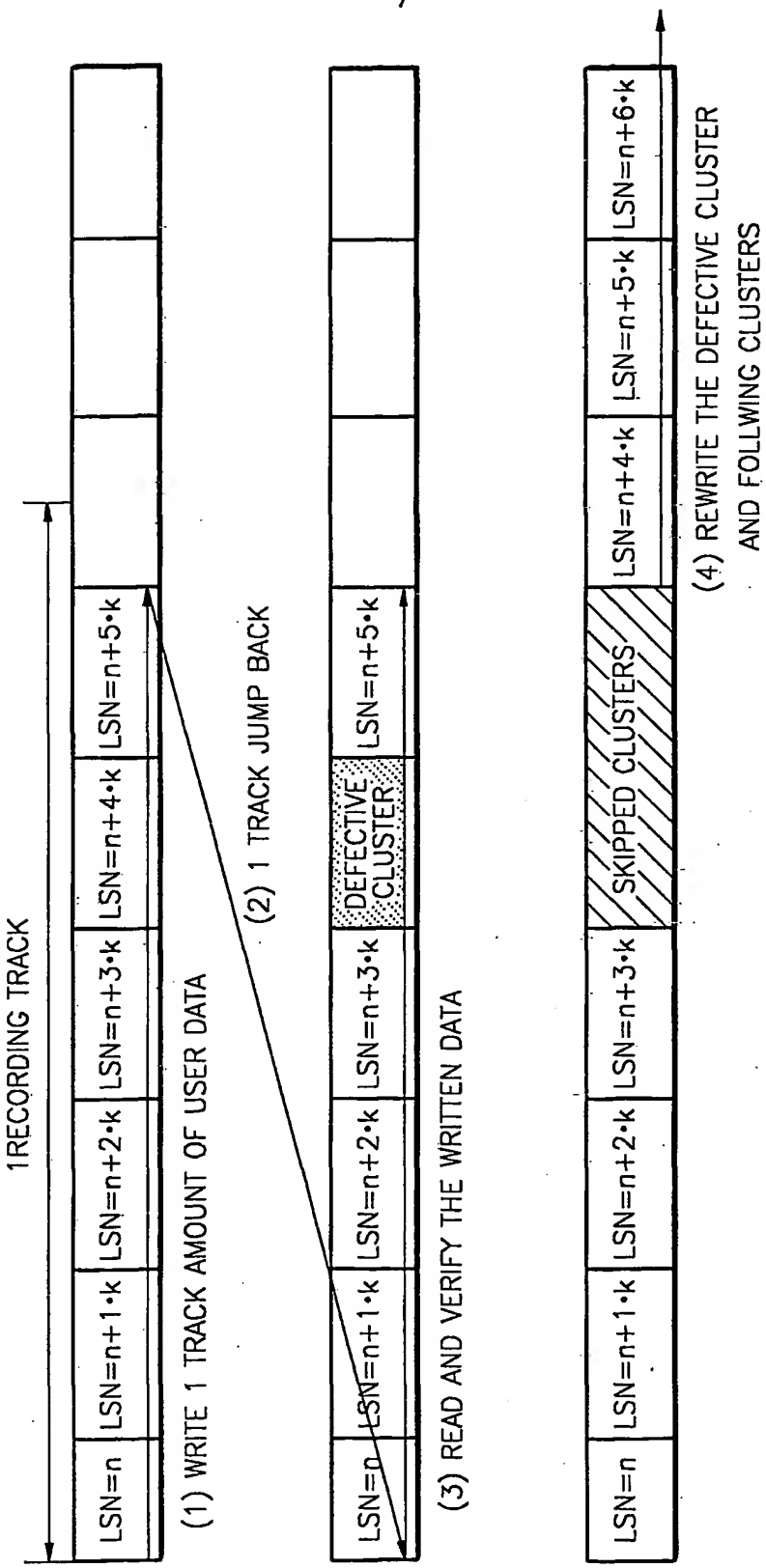

1RECORDING TRACK
LSN=n
LSN=n+1·k
LSN=n+2·k
LSN=n+3·k
LSN=n+4·k
LSN=n+5·k
(1) WRITE 1 TRACK AMOUNT OF USER DATA
(2) 1 TRACK JUMP BACK
DEFECTIVE CLUSTER
(3) READ AND VERIFY THE WRITTEN DATA
SKIPPED CLUSTERS
LSN=n+6·k
(4) REWRITE THE DEFECTIVE CLUSTER AND FOLLWING CLUSTERS

FIG. 2

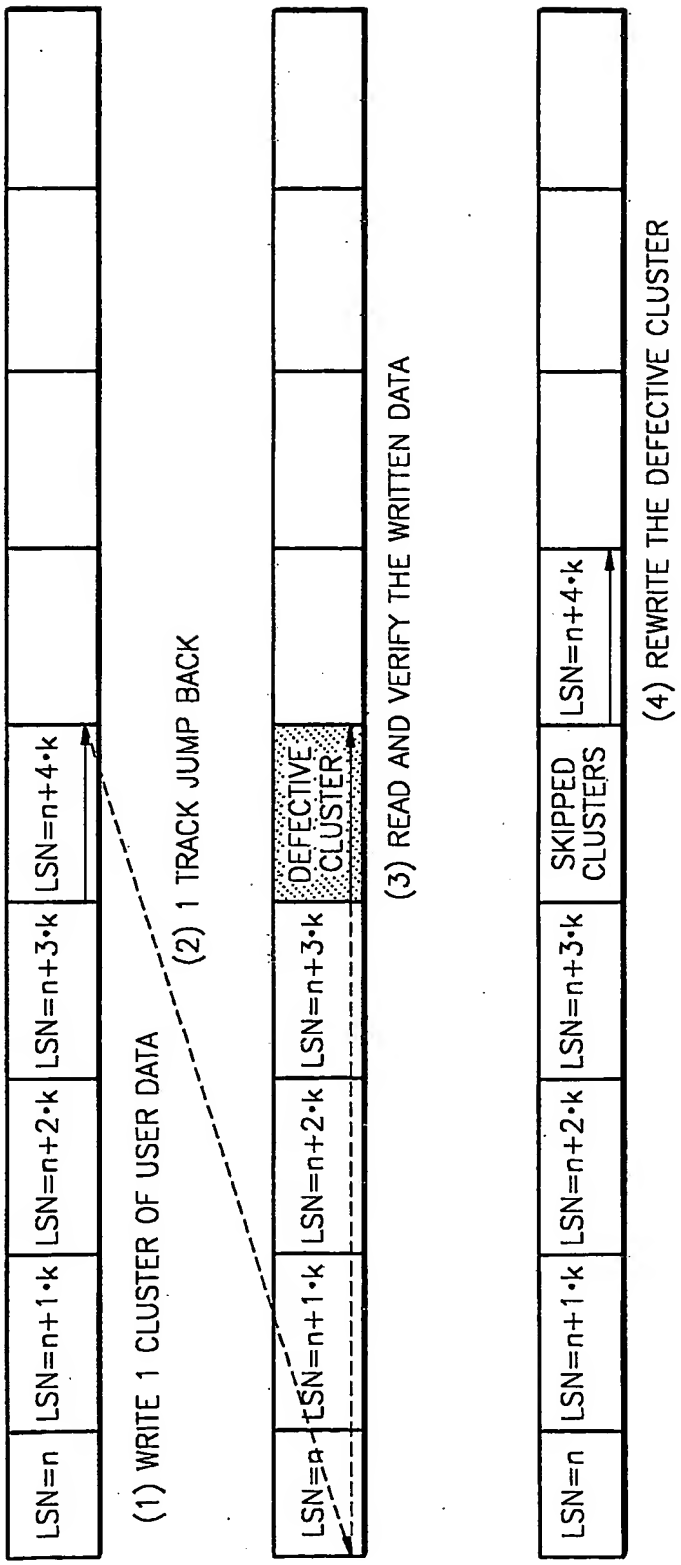

LSN=n
LSN=n+1·k
LSN=n+2·k
LSN=n+3·k
LSN=n+4·k
(1) WRITE 1 CLUSTER OF USER DATA
(2) 1 TRACK JUMP BACK
LSN=n
LSN=n+1·k
LSN=n+2·k
LSN=n+3·k
DEFECTIVE CLUSTER
(3) READ AND VERIFY THE WRITTEN DATA
LSN=n
LSN=n+1·k
LSN=n+2·k
LSN=n+3·k
SKIPPED CLUSTERS
LSN=n+4·k
(4) REWRITE THE DEFECTIVE CLUSTER

FIG. 3

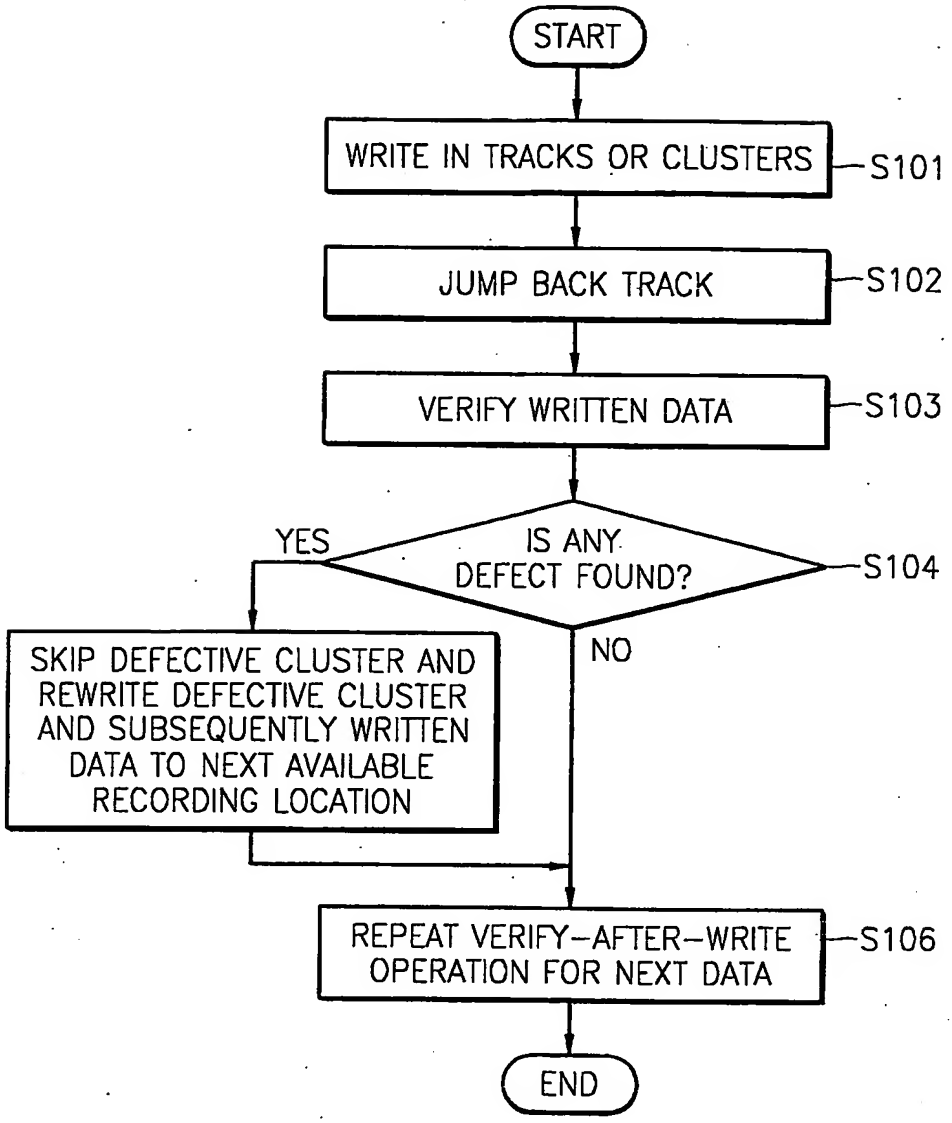
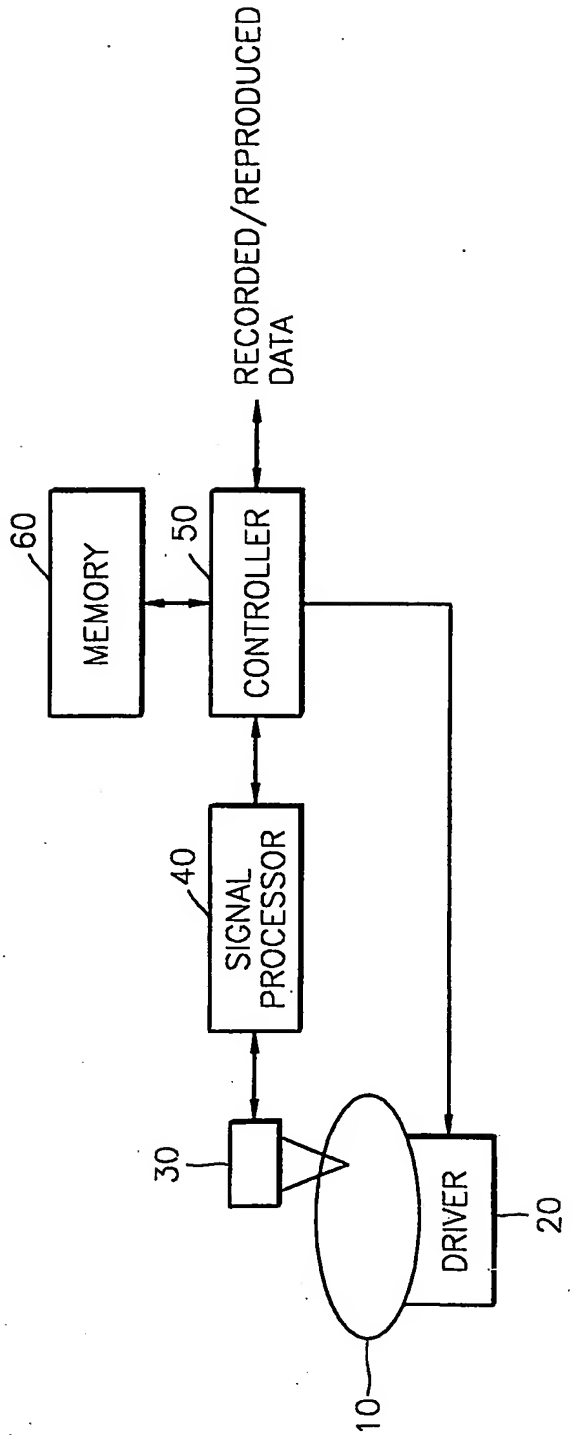

START
WRITE IN TRACKS OR CLUSTERS
S101
JUMP BACK TRACK
S102
VERIFY WRITTEN DATA
S103
IS ANY DEFECT FOUND?
S104
YES
NO
SKIP DEFECTIVE CLUSTER AND REWRITE DEFECTIVE CLUSTER AND SUBSEQUENTLY WRITTEN DATA TO NEXT AVAILABLE RECORDING LOCATION
REPEAT VERIFY-AFTER-WRITE OPERATION FOR NEXT DATA
S106
END

FIG. 4


RECORDED/REPRODUCED DATA
60
MEMORY
50
CONTROLLER
40
SIGNAL PROCESSOR
30
DRIVER
20
10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/01113

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G11B 20/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 G11B7/00 G11B20/10 G11B20/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975
Korean utility models and applications for utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ "defect, fault, error, record, write, verify, track, cluster"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR2002-0057729 A (LG ELECTRONICS CO LTD) 12 JUL 2002 See the whole document	5-8, 15-24
Y	JP2000-268511 A (SANYO ELECTRIC CO LTD) 29 SEP 2000 See the whole document	1-4, 9-13
A	KR1999-0075796 A (LG ELECTRONICS CO LTD) 15 OCT 1999 See the whole document	5-8, 15-25
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☐ Further documents are listed in the continuation of Box C.

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24 SEPTEMBER 2003 (24.09.2003)	24 SEPTEMBER 2003 (24.09.2003)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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